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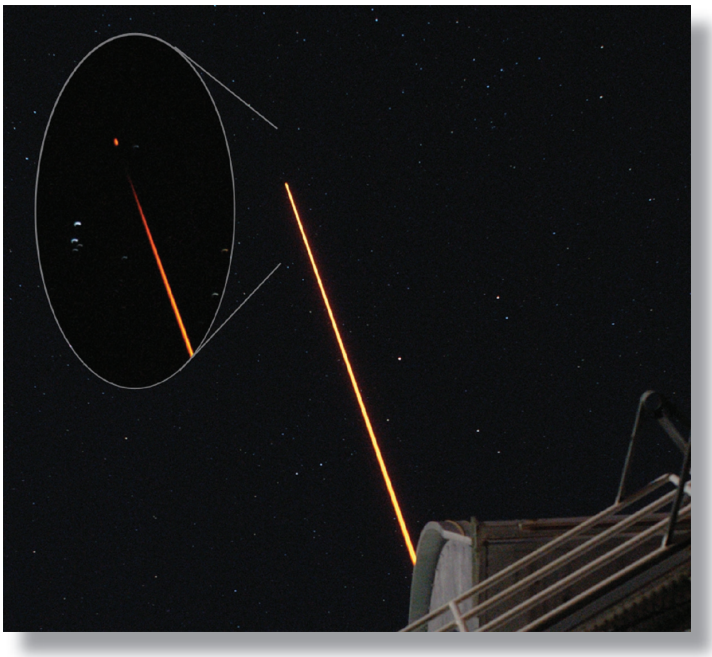
Science and Technology for Tomorrow's Air and Space Force

Success Story

DIRECTED ENERGY DIRECTORATE PRODUCES A 7.5 MAGNITUDE SODIUM GUIDESTAR FOR ADAPTIVE-OPTICS ATMOSPHERIC TURBULENCE CORRECTION



Directed Energy Directorate scientists from the High-Power Solid-State Lasers Branch and the Starfire Optical Range (SOR) produced an artificial guidestar in the mesosphere (90-kilometer altitude) with the radiance of a 7.5-magnitude star by exciting atomic sodium resident at that altitude with just 10 watts of projected power into the sky. Large ground-based telescopes equipped with adaptive optics can use a sodium guidestar to measure atmospheric turbulence and remove its distortions, enabling high-quality, ground-based observations of space objects and propagation of laser beams through a turbulent atmosphere. Astronomical imaging, using this technology, can rival the imaging capability of the Hubble Space Telescope.

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Accomplishment

Directorate scientists designed and built a solid-state laser system that produces world-record 20 watts of continuous power in a high-quality (diffraction-limited) beam at a wavelength of 589.159 nanometers—far exceeding the previous record of 0.4 watts. They achieved this by combining two infrared lasers (1064- and 1319-nanometer wavelengths) within an optical cavity containing a nonlinear-optical crystal of lithium triborate. The crystal added the frequencies of the two beams by a process known as sum-frequency generation.

Scientists then used this laser system to create the world's brightest continuous sodium guidestar in the mesosphere. The beam is highly visible in the photo as it leaves the SOR's beam director due to Rayleigh scattering from air molecules. The separate inset photo, obtained from a telescope camera view, shows the decrease in the Rayleigh scattering as the beam leaves the atmosphere and the guidestar. Future efforts include a high-power source designed to produce 50 watts. The project goal is to have a facility-class sodium guidestar pump laser operational on the SOR telescope by late 2004.

Background

The directorate's SOR at Kirtland Air Force Base, New Mexico, is researching the use of large ground-based telescopes to propagate laser beams through the atmosphere and to image satellites. To attain high intensity at the destination with the projected laser beam, the effects of the earth's atmospheric turbulence must be removed. Scientists can achieve this by using an adaptive-optics system that observes an artificial guidestar to measure the atmospheric distortions and compensate for them. The mesospheric sodium guidestar is especially useful for greater than 3-meter-diameter, ground-based telescopes because of its higher altitude compared to Rayleigh beacon guidestars.

Development of this laser attracted the attention of the international astronomy community, and the directorate plans to transition this guidestar technology to large ground-based telescopes around the world. For example, the Gemini Observatory, a 7-nation partnership including the US, built two 8-meter, world-class telescopes on Mauna Kea, Hawaii and at Cerro Pachon, Chile, to provide complete sky coverage of the Northern and Southern Hemispheres. Each will require at least one sodium guidestar to achieve their full imaging resolution potential.

Directed Energy
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Additional information

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